REMARKS

This paper is responsive to an Official Action that was issued in this case on January 3, 2006 and accompanies a Request for Continued Examination. In the Action, claims 1 through 31 were finally rejected, as follows:

- Claims 1-4, 6-9, 16-18, and 21-22 were rejected under 35 USC §102 as being anticipated by U.S. Pat. No. 6,580,864 to Temkin *et al.*
- Claims 10-13, and 29 were rejected under 35 USC §102 as being anticipated by U.S. Pat. No. 5,732,179 to Caneau *et al.*
- Claims 5, 19-20 were rejected under 35 USC §103 as being obvious over Temkin *et al.*
- Claims 14-15, 30 and 31 were rejected under 35 USC §103 as being obvious over Caneau *et al.*
- Claims 23-28 were rejected under 35 USC §103 as being obvious over Caneau *et al.* in view of U.S. Pat. No. 6,704,487 to Parhami *et al.*

Claim 16 has been amended; claims 1-31 are still pending. Before turning to the language of the claims, the following overview is provided. The overview explains why the cited art is not relevant to the pending claims.

Overview

The references that have been cited by the Office (Parhami *et al.*, Caneau *et al.*, and Temkin *et al.*) pertain to specific waveguide structures that are different from applicant's claimed waveguide and from one another. These differences are such that it is not appropriate to apply these references individually as a basis for a Section 102 rejection or collectively as the basis for a Section 103 rejection of applicant's claims.

The **Parhami *et al.*** reference pertains to methods and systems for reducing thermally-induced birefringence in *thermo-optic* PLCs (planar light-wave circuits).

Thermo-optic PLCs incorporate heating elements that are used to modulate an accumulated phase difference between optical signals that are propagating through different waveguides within the PLC. The heating elements modulate phase by selectively heating the waveguides through which the signals travel. In particular, heating the waveguides changes their relative refractive indices. (*See*, *e.g.*, col. 2, lines 33-51.) The Parhami *et al.* reference discloses that the heat supplied by the heating elements induces stress within the

waveguides, which results in birefringence. (*See*, *e.g.*, col. 2, line 52 through col. 3, line 13.) This is thermally-induced birefringence.

Parhami *et al.* discloses that in the prior art, the *intrinsic birefringence* of the waveguide structure is controlled, but not thermally-induced birefringence. Parhami *et al.* also discloses that prior art solutions to the problem of intrinsic birefringence involve additional film deposition steps. (*See*, *e.g.*, col. 3, lines 26-32.)

The Parhami *et al.* solution addresses the problem of *thermally-induced* birefringence in "active" PLCs. Parhami *et al.* does <u>not</u> address the problem of intrinsic birefringence in passive waveguides, which is a distinct problem having distinct solutions. As stated in Parhami *et al.*:

> The present invention is a method and system for reducing dn/dt birefringence in a thermo-optic PLC device. The present invention provides a solution that matches the TE and TM propagation modes of an optical signal within active PLC devices. The present invention minimizes thermally induced dn/dt birefringence within thermo-optic PLC devices. Additionally, the present invention does not add additional film deposition steps to the PLC device fabrication process.

(Parhami *et al.,* at col. 3, lines 40 – 49.)

Some key differences between Parhami *et al.* and applicants' invention are as follows:

- Applicant's invention pertains to *passive* waveguides, not active devices such as the thermo-optic PLC of Parhami *et al.*
- Applicant's invention pertains to the control of *intrinsic* birefringence, not thermally-induced birefringence as in Parhami *et al.*
- And applicant's invention involves, at least in some embodiments, depositing additional films to the waveguide deposition process. The Parhami *et al.* invention explicitly teaches away from adding film deposition steps to control birefringence.

Caneau *et al.* discloses a birefringence-free *semiconductor* waveguide. These waveguides comprise materials that are group III-V and group II-VI semiconductors. The birefringence that is introduced by a given amount of strain in a semiconductor layer is a function of the

separation between the bandgap energy of the semiconductor material and the photon energy of the light experiencing the birefringence.

Applicant's claimed waveguides comprise oxides and nitrides, not group III-V and group II-VI semiconductors. There are different considerations as to stress control in semiconductor waveguides versus oxide waveguides.

For example, the functional dependence that is exhibited in semiconductor waveguides as described above is not exhibited in the oxides used in applicant's invention. Furthermore, semiconductor layers can be deposited with or without strain as a function of lattice matching to the underlying layer. There will always be stress in a deposited oxide or nitride.

Temkin *et al.* discloses birefringence-free optical waveguide structures. Temkin *et al.* teaches that by doping the upper and lower cladding layers of the waveguide with appropriate levels of phosphorous and boron, a substantially birefringence-free optical core results.

In particular, Temkin *et al.* discloses that to create a birefringence-free waveguide that has phosphorous- and boron-doped upper and lower cladding layers, the cladding layers must be capable of: (1) being deposited on silicon; (2) have an appropriate combination of index of refraction and thermal coefficient of expansion; and (3) must anneal to form high-quality glass with low optical loss and strain. (*See*, col. 4, lines 1-8.)

Temkin *et al.* discloses that the ability to change the sign of the stress (*i.e.*, compressive ↔ tensile) in the cladding layers is crucial to the design and preparation of substantially birefringence-free optical waveguides. (*See*, col. 4, lines 20-23.) Working from the dependence of the index of refraction on phosphorous concentration (FIG. 4) and the dependence of the thermal expansion coefficient on boron concentration (FIG. 2), Temkin *et al.* discovers a concentration range for phosphorous and boron in silicon dioxide cladding that provides essentially birefringence-free optical waveguides. (*See*, *e.g.*, col. 4, lines 35 through 44 and FIG. 3.)

Temkin *et al.* discloses that at concentrations of phosphorous and boron that are higher than the preferred range, the doped silicon-dioxide cladding becomes thermodynamically unstable and might not convert to high-quality glass. Temkin *et al.* also discloses that at concentrations of phosphorous and boron that are lower than the preferred range, biaxial stress and birefringence tend to increase. (*See*, col. 4, lines 45-53.)

Some key differences between Temkin *et al.* and applicants' invention include:

- Temkin *et al.* uses specific concentrations of phosphorus and boron dopants to achieve zero residual stress in the optical core, whereas the claimed invention avoids the use of dopants. Controlling dopant levels, especially in the relatively thick cladding layers around the optical core, is notoriously difficult. This results in run-to-run variations and a non-uniform distribution of dopant throughout the cladding. Due to these difficulties, the Temkin *et al.* approach is costly to implement at the commercial scale.
- Temkin *et al.* addresses birefringence by appropriately doping the *cladding layers*. In applicant's claimed invention, stress control is implemented by altering the geometry and thickness of layers <u>within the composite guiding region itself</u>.

This general overview was intended to provide the Examiner with a further appreciation as to how the cited art differs from applicant's invention and why, generally, it is not appropriate to reject the applicant's pending claims under 35 USC §§ 102 or 103 based on the teachings of these references.

We turn now to the specifics of the claim language and the claim rejections.

I. Rejections under 35 USC §102

Claims 1-4, 6-9, 16-18,
and 21-22 are Allowable
<u>over Temkin *et al.*</u>

Independent claim 1 recites an article comprising:

> a composite guiding region having at least three layers, wherein
> two of said three layers have stress of the same sign;
> said two layers are separated by one or more interposed layers;
> said one or more interposed layers have stress of opposite sign relative to said two layers; and
> said interposed layers are suitable for guiding light based on the relative refractive indices of said interposed layers and said two layers.

The Office alleges that Temkin *et al.* discloses an optical device that has all the limitations that are recited in the claims. In particular, the Office alleges that Temkin *et al.* possesses

"a composite guiding region having at least three layers, lower and upper cladding layers having stress of the same sign ...; said lower and upper cladding layers are separated by one or more core layer, which has stress of opposite sign...."

Applicant disagrees with this characterization of Temkin *et al.* In particular, it is apparent that the Office considers the cladding layers to be part of the "composite guiding region." Yet, that is inconsistent with applicant's definition. At para. [0031] of applicant's specification, it is stated that:

> Stripe waveguide **100** comprises composite guiding region **106**, which is surrounded by lower cladding layer **102** and upper cladding layer **104**. ...the lower and upper cladding layers serve to confine propagating light to composite guiding region **106**."

This is depicted in Figure 1. The specification goes on to disclose at para. [0034], and with referenced to Figure 2, that:

> composite guiding region **106** comprises layers **208**, **210**, and **212**. Layers **208** and **212** sandwich interposed layer **210**. Composite guiding layer **106** is itself sandwiched by lower cladding layer **102** and upper cladding layer **104**.

And it is further disclosed at para. [0036] that:

> In stripe waveguide **100**, the residual stresses of layers **208**, **210**, and **212** are used to tailor the stress in composite guiding region **106**.

Thus, when claim 1 recites a composite guiding layer "having at least three layers" that possess certain stress characteristics, it is the layers **208**, **210**, and **212**, <u>not</u> the cladding layers **102** and **104**, which are being referenced.

Temkin *et al.*, on the other hand, discloses tailoring the stress *in the cladding layers* to affect the stress in core (the core being the most appropriate analogue to applicant's claimed "composite guiding region").

Temkin *et al.* does not, therefore, disclose what is recited in claim 1. As a consequence, the Office is requested to withdraw the Section 102 rejection of claim 1 over Temkin *et al.* Since claims 2 through 9 are dependent on claim 1, those claims are allowable over Temkin

et al. as well. The recitation of additional patentable features in claims 2 through 9 provides a secondary basis for their patentability.

It is noted that claims 1 through 10 cannot be considered to be obvious, under Section 103, over Temkin *et al.*, for the reasons discussed in the Overview section. In particular, among any other distinctions, Temkin *et al.* relies on <u>dopant levels in the cladding layers</u> to tailor stress in the optical core. That disclosure cannot reasonably be said to suggest applicant's claimed invention wherein the <u>thickness and geometry of non-doped layers within the composite guiding region are used to tailor the stress</u>. (*See, e.g.*, para. [0045]).

Independent claim 16, as amended, recites a method of forming a surface waveguide comprising:

> forming a composite guiding region, wherein forming said composite guiding region comprises:
>
> depositing on a surface of a substrate a first conformal layer comprising a first material having a first stress;
>
> depositing on said first conformal layer a second conformal layer comprising a second material, wherein said second material has a second stress of opposite sign relative to said first stress;
>
> depositing on said second conformal layer a third conformal layer of a third material, wherein said third material has a third stress of the same sign relative to said first stress.

This claim recites forming a *composite guiding region* by depositing three conformal layers, one on top the next, wherein a stress in the first and third-deposited layers has the same sign, and the stress in the second-deposited layer has a stress of opposite sign. Temkin *et al.* does not disclose or suggest what is recited in amended claim 16.

As previously discussed, applicant has defined the phrase "composite guiding region" to <u>exclude</u> cladding layers. Temkin *et al.* does NOT disclose the deposition of three conformal layers to form a composite guiding region. Rather, Temkin *et al.* discloses the deposition of a first phosphorous and boron-doped layer to form the lower cladding, a second phosphorous and boron-doped layer to form the optical core (*i.e.*, analogous to the composite guiding region), and a third phosphorous and boron-doped layer to form the upper cladding layer.

Amended claim 16 is therefore allowable over Temkin *et al.* Since claims 17-28 are dependent, ultimately, on claim 16, those claims are allowable as well. The recitation of additional patentable subject matter in claims 17-28 provides a secondary basis for their patentability.

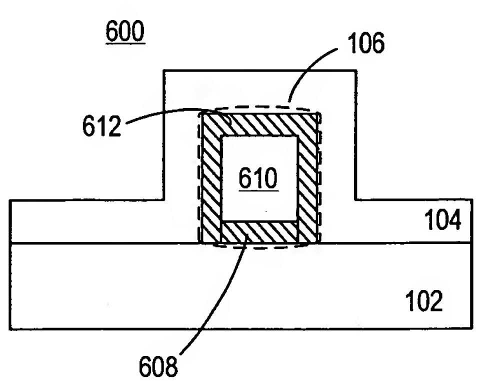
Claims 10-13 and 29 are Allowable <u>over Caneau *et al.*</u>

Independent claim 10 recites a surface waveguide comprising:

> a lower cladding layer comprising a lower cladding material; and
> *a core comprising an inner core and an outer core*, wherein:
> said inner core comprises one or more layers of inner core material;
> said inner core material supports propagation of light;
> said inner core material has a first stress;
> *said outer core surrounds said inner core*; and
> said outer core comprises an outer core material having a second stress of opposite sign relative to said first stress; and
> an upper cladding comprising an upper cladding material, wherein said lower cladding material and said upper cladding material have indices of refraction lower than the index of refraction of said outer core material.

(emphasis added.)

The Figure below, which is based on Figure 6 of the instant application, depicts an "inner core" (inner core **610**) surrounded by an outer core, as recited in claim 10. The outer core, which is cross-hatched for clarity, comprises lower layer **608** and upper layer **612**, which extends over the top and sides of inner core **610**. (*See*, p. 12, para. [0061].)



The Office alleges that Caneau *et al.* discloses "a core comprising an inner core and an outer core (2 layers), wherein the inner [core] ... has a first stress (tensile or compressive); outer core surrounding (in planar configuration) and ... having a second stress (tensile or compressive) of opposite sign relative to the first stress."

This characterization is of Caneau *et al.* is inaccurate. First, Caneau *et al.* depicts a core having a <u>layered arrangement</u>. There can be no argument that in a layered arrangement, one layer cannot be said to "surround" another layer. The American Heritage Dictionary of the English Language (3d. ed) defines "surround" as follows: "1. To extend on all sides of simultaneously; encircle. 2. To enclose or confine on all sides ...."

So, regardless of whether or not the top and the bottom layer of the core are considered to be an "outer core," as suggested by the Office, those layers don't "surround" the second and third layers (the "inner core"). The first and fourth layers can be said to *sandwich* the second and third layers, but they certainly do not to *surround* them.

Second, Caneau *et al.* discloses that the layers **18** in core **14** are alternately tensilely strained layers and compressively strained layers. See, for example, FIG. 9, wherein layers **63** in core **14** are tensilely strained and alternate layers **64** are compressively strained. (Col. 11, lines 45-50.) Recall that the Office alleges that the top and bottom layers of core **14** define the "outer core." As a consequence, the outer core would have a bottom portion (bottom layer **63**) that is tensilely strained and an upper portion (top layer **64**) that is compressively strained. But this is not what is recited in claim 10.

Furthermore, claim 10 recites that the outer core and the inner core have stress of opposite sign. But the inner core, which would comprise the second layer **64** and third layer **63** according to the Office's view of Caneau *et al.*, would include both a compressively strained layer (layer **64**) and a tensilely strained layer (layer **63**). So, in the waveguide that is disclosed in Caneau *et al.*, it cannot be said that the inner core and the outer core have a stress of opposite sign.

In view of the foregoing, claim 10 is allowable over Caneau *et al.* Due to their dependence on claim 10, claims 11-15 are likewise allowable. The recitation of additional patentable subject matter in claims 11-15 provides a secondary basis for their patentability. The Office is therefore requested to withdraw the rejection of claims 10-13 under Section 102, as premised on Caneau *et al.*

Claim 29 recites a method comprising:

> forming a composite guiding region comprising an inner core of a first material surrounded by an outer core of a second material wherein:
>
> said inner core has a first stress; and
>
> said first material supports propagation of light; and
>
> said outer core has a second stress having opposite sign relative to said first stress; and
>
> said second stress compensates said first stress such that the modal birefringence of said composite guiding region is less than 0.0001.

Claim 29 is allowable over Caneau *et al.* for at least some of the same reasons that claim 10 is allowable over that reference. In particular, Caneau *et al.* does not disclose (or suggest):

- a composite guiding region comprising an inner core *surround*ed by an outer core;
- an outer core that has a stress that is opposite in sign to that of the inner core.

Claims 30 and 31, which recite a dependency to claim 29, are likewise allowable. For these reasons, among any others, the Office is requested to withdraw the Section 102 rejection of claim 29.

II. Rejections under 35 USC §103

Claims 5 and 19-20
are Allowable
over Temkin *et al.*

The Office admitted that Temkin *et al.* does not "explicitly teach the use of stoichiometric silicon nitride and silicon dioxide as cladding or core layers of the optical waveguide." But, the Office alleged that the use of these materials is well known and would therefore have been obvious to use.

The problem with this argument should be clear in view of the foregoing discussion. In the first place, claims 5 and 19-20 are allowable based on their dependence on respective base claims 1 and 16, which are neither anticipated nor obvious over Temkin *et al.*

Secondly, the Temkin *et al.* invention pertains to using a specific range of phosphorous and boron in TEOS or HIPOX based cladding layers. One cannot simply substitute stoichiometric materials for these doped layers. Using stoichiometric cladding layers would do little to control stress and birefringence in the composite guiding region.

For these reasons, among others, claims 5 and 19-20 are not obvious in view of Temkin *et al.* The Office is therefore requested to withdraw the Section 103 rejection of these claims.

Claims 14-15 and
30-31 are Allowable
over Caneau *et al.*

The Office admitted that Caneau *et al.* does not "explicitly teach the use of stoichiometric silicon nitride and silicon dioxide as cladding or core layers of the optical waveguide." But, the Office alleged that the use of these materials is well known and would therefore have been obvious to use in conjunction with the Caneau *et al.* invention.

Once again, it should be clear that Caneau *et al.* provides no teaching relevant to applicant's claimed invention. Caneau *et al.* pertains to waveguides that comprise group II-VI and group III-V semiconductor materials, not those comprised of oxides and nitrides of silicon. No one skilled in the art would try to substitute oxides and nitrides for the semiconductors in the Caneau *et al.* waveguide because the Caneau *et al.* teachings are inapplicable to oxide/nitride-based waveguides.

For these reasons, among any others, claims 14-15 and 30-31 are not obvious in view of Caneau *et al.* The Office is therefore requested to withdraw the Section 103 rejection of these claims.

Claims 23-28 are Allowable
over the Combination of
Caneau *et al.* and Parhami *et al.*

The Office admitted that Caneau *et al.* does not disclose steps pertaining to the removal of waveguide layer materials. But the Office alleges that Parhami *et al.* teaches the removal of waveguide layer materials and the formation of trenches.

Claims 23 through 28 are allowable based on their dependence on claim 16, which is allowable over either Caneau *et al.*, Parhami *et. al.*, or the combination thereof. As discussed in the Overview section, Parhami *et al.* pertains to controlling thermally-induced birefringence and no one skilled in the art would be motivated to apply such teachings to a passive waveguide to control intrinsic birefringence.

More particularly, and among other differences, Parhami *et al.* discloses forming "stress-relief" trenches adjacent to a waveguide core to relieve lateral stress in the core. The trenches are filled with a thermo-optic material that enables one to *actively* affect the stress

configuration in the waveguide core. This approach cannot be applied to the claimed invention, which is completely passive.

Furthermore, it is noted that Parhami *et al.* disclose adding a cap layer over the core to allegedly balance the stress in the optical core. The cap layer is not present below the waveguide core and, as a consequence, the stress within the core could not be completely controlled. For Parhami *et al.*, that might not be critical since stress control is primarily active via the trenches. But this technique could not be applied for stress control in a passive waveguide structure, such as applicant's claimed invention.

It is notable that the addition of a cap layer to the top of the core, but not beneath the core, would produce a gradient in lateral stress that extends vertically through the core.

As a consequence, claims 23-28 are not obvious over the combination of Caneau *et al.* and Parhami *et al.* The Office is therefore requested to withdraw the Section 103 rejection of these claims.

Summary

It is believed that claims 1-31 now presented for examination are allowable over the art of record. A notice to that effect is solicited.

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